2 EMISSIONS

This section summarizes the Potential To Emit (PTE) for the project. Detailed calculations are provided in Appendix B.

2.1 Turbine Emissions

The proposed project consists primarily of installing a single new, gas-fired, low-NO_x Solar Centaur 50-6200LS compressor turbine equipped with a SoLoNOx™ combustor and rated at 6,130 hp (ISO). Annual emissions are calculated based on operating the unit at 8,760 hours a year at three (3) different operating modes:

1) At an annual average ambient temperature of 40 °F for 8,460 hours;
2) At subzero conditions between 0 °F and -20 °F during the wintertime for 300 hours, and;
3) Startup and shutdown events.

Emissions from operation in each of these three modes are further described in the following sections.

2.1.1 Typical Operations

The turbine manufacturer (Solar Turbines) guarantees the exhaust concentrations of the most prevalent pollutants—oxides of nitrogen (NO_x), carbon monoxide (CO), and unburned hydrocarbons (UHC)—in units of parts per million by volume, dry basis, corrected to 15% oxygen (ppmvd @ 15% O_2) as follows:

25 ppmvd NO_x @ 15% O_2
50 ppmvd CO @ 15% O_2
25 ppmvd UHC [2] @ 15% O_2

The warrantees apply to the following wide range of operating conditions: ambient temperatures above 0 °F, and gas fuel loads ranging from 50% to 100%. EPA emission factors were used to estimate emissions of other pollutants, including sulfur dioxide (SO_2), particulate matter (PM), and hazardous air pollutants (HAPs).[3]

Translation of these concentrations and emission factors into short term emission rates (pounds per hour, lb/hr) depends on the density of the ambient air, which in turn depends on the ambient air temperature (see Table 2-1).

[2] UHC for turbine emissions is provided by Solar and is inclusive of methane and ethane

[3] Factors for SO_2 and PM are from US EPA, "Stationary Gas Turbines," Section 3.1 of AP 42, Fifth Edition, Volume I, available on the internet at <http://www.epa.gov/ttn/chief/ap42/ch03/final/c03s01.pdf>, last revised April 2000; the emission factor for HAP is from EPA docket OAR-2002-0060, "Revised HAP Emission Factors for Stationary Combustion Turbines" (document ID IV-B-09), 8/22/03, as reported in Solar Turbines, "Volatile Organic Compound, Sulfur Dioxide, and Formaldehyde Emission Estimates," Product Information Letter (PIL) 168, 8 October 2003 (see Appendix C).

Table 2-1. Maximum Hourly Emissions from each Turbine as a Function of Ambient Temperature.[a]										
Gas Fuel Load (%)	Ambient Temperature (°F)	Net Output Power (hp)	Heat input rate (MMBtu/hr)		Maximum hourly emissions (lb/hr)					
			LHV[b]	HHV[b]	NO_x (as NO_2)	CO	UHC[c]	SO_2	PM[d]	HAP
100	0	6703	54.5	60.5	5.57	6.79	1.94	0.21	0.40	0.18
	40	6346	52.2	57.9	5.34	6.50	1.86	0.20	0.38	0.18

[a] All values shown are for an elevation of 200 feet and relative humidity of 60%.
[b] LHV = Lower (net) Heating Value; HHV = Higher (gross) Heating Value.
[c] Emissions of Volatile Organic Compounds (VOC) have been conservatively assumed to be identical to emissions of UHC, even though UHC is comprised of ~ 80 – 90% CH_4/C_2H_6. [d] All PM emissions are assumed to be smaller than 10 microns in diameter.

The hourly emission rates corresponding to 0 °F represent the worst case short term emission rates. The annual emissions are based on the short-term emission rate at 40 °F for 8,460 hours/year with consideration of the emission corresponding to subzero conditions as presented below for the remaining 300 hours of the year.

2.1.2 Operations at Ambient Temperatures Below 0 Degrees Fahrenheit

As stated above, vendor guarantees only apply to ambient temperatures of 0 °F and above. Ambient temperatures below 0 °F in the last six years are summarized in Table 2-2. Below 0 °F, SoLoNOx combustors are generally configured to increase the proportion of the fuel to the pilot to augment flame stability, which can also increase concentrations of NO_x, CO, and UHC in the exhaust. Vendor guarantees are not available at these temperatures, but the vendor has estimated that between -20 °F and 0 °F, the concentrations are 42 ppm, 100 ppm, and 50 ppm, respectively[4]. It should be noted that while historical meteorological data shows several occurrences of temperature below 0 °F, from 2000-2004 temperatures recorded at the meteorological station identified in Table 2-2 have never been b. low -20 °F.

The maximum heat input rate also increases as temperature decreases for all load cases. Conservative estimates of maximum hourly emissions at ambient temperatures between -20 °F and 0 °F are based on a heat input rate of 62 MMBtu/hr (HHV) at 100% load.

[4] Solar Turbines, "SoLoNOx Products – Emissions in Non-SoLoNOx Modes," Product Information Letter (PIL) 167, 9 January 2003 (see Appendix C).

Table 2-2. Hours of Ambient Temperatures Below 0 °F (Concord, NH Met Station 46)				
Year	December	January	February	March
2004	14	137	16	14
2003	1	97	62	16
2002	2	0	4	2
2001	6	24	3	4
2000	8	69	8	0

Table 2-3. Maximum Hourly Turbine Emission Concentrations at -20 °F to 0 °F.			
MMBtu/hr (HHV)	Maximum hourly emissions (ppm)[a]		
	NO_x (as NO_2)	CO	UHC
60.5	42	100	50

[a] From Solar Turbines Product Information Literature 167.

2.1.3 *Startup and Shutdown Operations*

During startup and shutdown (i.e., operating loads between 0% and 50%), exhaust concentrations can be in excess of the concentrations that are guaranteed for normal operation loads of 50%-100%. The vendor does not provide guarantees for emissions during startup and shutdown, but has estimated the exhaust concentrations,[5] which are shown in Table 2-4 along with conversions to emission factors (lb/MMBtu).

Table 2-4. Estimated Concentrations and Emission Factors During Startup and Shutdown						
Description	Concentrations (ppmv)			Emission Factors (lb/MMBtu)[a]		
	NO_x	CO	UHC	NO_x	CO	UHC
Startup Ignition, idle, synchronization (approx. 3 min.)	50	3500	500	0.18	7.8	0.64
Loading and thermal stabilization (approx. 6 min.)	70	2200	300	0.26	4.9	0.38
Shutdown (approx. 5 min.)	70	2200	300	0.26	4.9	0.38

[a] HHV basis; calculated from EPA Method 19, Equation 19-1, assuming that all concentrations are dry basis at 15% O_2.

[5] Solar Turbines, "Emission Estimates at Start-up, Shutdown, and Commissioning for SoLoNOx Products," Product Information Letter (PIL) 170, 27 January 2003 (see Appendix C).

Worst-case hourly emission rates for startup and shutdown emissions at 0 °F and 40 °F are shown in Table 2-5 and were determined by applying heat input rates at 50% load to the emission factors for all startup and shutdown activities shown in Table 2-4, and assuming that the turbines operate at 100% load for the remainder of the hour.

Table 2-5. Hourly Emissions (lb/event) During Startups and Shutdowns			
	NO_x	CO	UHC
Startup and Shutdown	1.1	23	1.9

2.1.4 Potential Annual Emissions

The potential annual emissions from the proposed turbines are estimated in Table 2-6, based on operations occurring for 8760 hours per year at full load and a conservative annual average ambient temperature of 40 °F.[6] The increases associated with a maximum of 250 startup and shutdown events have been added to these emissions. Additionally, the incremental emissions associated with operating below 0 °F have been added in; it was conservatively assumed that such operations could occur for up to 300 hours per year, even though Table 2-2 shows that such conditions have not recently exceeded 200 hours per year. Table 2-6 shows the potential annual emissions from the new turbine at 100% load.

Table 2-6. Potential annual emissions from new turbine (tons per year or TPY).							
Gas Fuel Load (%)		NO_x (as NO_2)	CO	UHC	SO_2	PM	HAP
100	Annual emissions for turbine at T = 40 °F year-round	23.4	28.5	8.1	0.9	1.7	0.8
	Incremental emissions associated with 250 startups and 250 shutdowns	0	2.69	0.18	0	0	0
	Additional emissions for turbine if T < 0 °F for 300 hr/yr	0.5	1.0	0.3	0	0	0
	Total emissions from turbine	23.9	32.1	8.6	0.9	1.7	0.8

2.2 Auxiliary Generator Emissions

In addition to the compressor turbine, the permit application covers installing an emergency generator to be used as an auxiliary power source. The make and model of the emergency generator have not been finalized; however, the selected generator will be manufactured after January 1, 2009 and the horsepower capacity will not exceed 425 hp. This generator will be limited in operation to no more than 500 hours a year.

2.2.1 Typical Operations

The emergency generator will comply with the recently promulgated New Source Performance Standards (NSPS) Subpart JJJJ for emergency engines manufactured after January 1, 2009 (see Section 3.1.3). The

[6] The annual average ambient temperature measured between 2000-2004 at the nearest surface meteorological monitoring station in Concord, NH has been 46.7 °F.

NSPS provide exhaust emission limits for the regulated pollutants, NO_x, CO, and Volatile Organic Compounds (VOC) in units of grams per horsepower-hour as follows:

2.0 g/hp-hr NO_x
4.0 g/hp-hr CO
1.0 g/hp-hr VOC [7]

EPA emission factors were used to estimate emissions of other pollutants, including SO_2, and PM.[8]

Table 2-7. Maximum Hourly Emissions from the Emergency Generator.

Net Output Power (hp)	Heat input rate (MMBtu/hr)		Maximum hourly emissions (lb/hr at full load)				
	LHV	HHV	NO_x (as NO_2)	CO	VOC (NM/NE UHC)	SO_2	PM[a]
425	4.21	4.68	1.87	3.75	0.94	0.003	0.05

[a] All PM emissions are assumed to be smaller than 10 microns in diameter.

2.2.2 *Potential Annual Emissions*

The potential annual emissions from the proposed auxiliary generator are estimated in Table 2-8, based on 500 hours of operation per year. These emissions have been calculated conservatively, assuming that the auxiliary generator is operating at an ambient temperature greater than 0 °F under 100% load with fan, which is considered normal operating conditions.

Table 2-8. Potential Annual Emissions from the Emergency Generator

	NO_x (as NO_2)	CO	VOC (NM/NE UHC)	SO_2	PM
Total emissions from generator based on 500 hr/year operation	0.47	0.94	0.23	0.0007	0.0117

2.3 Other Auxiliary Sources

In addition to the installation of the gas-fired Solar Centaur compressor turbine and the emergency generator, the proposed project will also include a gas-fired fuel gas heater, gas-fired space heaters, and a gas-fired water heater, rated at no more than 1.5 MMBtu/hr, 1.5 MMBtu/hr, and 1.0 MMBtu/hr heat input, respectively. The combined estimated heat input from all other sources totals 4.0 MMBtu/hr. It is assumed that these sources will be in operation year-round (8760 hours per year).

[7] In the final rule NSPS Subpart JJJJ, VOC is defined as provided in 40 CFR 51, that is, non-methane, non-ethane HC and formaldehyde are excluded from the VOC emission calculation.

[8] Factors for SO_2 and PM are from US EPA, "Stationary Gas Turbines," Section 3.1 of AP 42, Fifth Edition, Volume I, available on the internet at <http://www.epa.gov/ttn/chief/ap42/ch03/final/c03s01.pdf>, last revised April 2000.

2.3.1 *Typical Operations*

Hourly emissions for NO_x, CO, VOC, SO_2, and PM for the fuel gas heater, space heaters, and the water heater were determined using US EPA AP-42 Emission Factors for Natural Gas Combustion and the known combined heat input of 4.0 MMBtu/hour. Emission factors for NO_x and CO were chosen based on the selection of an uncontrolled small boiler as the combustion source type. Maximum hourly emissions from these sources were calculated under normal operating conditions at ambient temperature. Estimated hourly emissions may change subject to variation in equipment selection, facility and/or engine fuel system adjustments. Table 2-9 shows the maximum emissions from these auxiliary sources.

Table 2-9. Maximum Hourly Emissions from Other Auxiliary Sources. (lb/hr at full load)

Heat Input (MMBtu/hr)	NO_x (as NO_2)	CO	VOC (NM/NE HC)	SO_2	PM[a]
4.0	0.39	0.33	0.022	0.0024	0.03

[a]All PM emissions are assumed to be smaller than 10 microns in diameter.

2.3.2 *Potential Annual Emissions*

The potential annual emissions from the other auxiliary sources are estimated in 2-10, assuming that they are in operation 8760 hours per year. These emissions have been calculated conservatively, assuming that the auxiliary sources are operating at an ambient temperature greater than 0 °F under 100% load, which is considered normal operating conditions.

Table 2-10. Potential Annual Emissions from the Fuel Gas Heater, Space Heater, Water Heater

	NO_x (as NO_2)	CO	VOC (NM/NE HC)	SO_2	PM
Total emissions from auxiliary sources based on 8760 hr/year operation	0.429	0.361	0.024	0.003	0.033